Optimal Cash Management for ATM Center by Genetic Algorithm

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***Abstract*—Automated Teller Machines are one of the most important cash distribution channels for the banks. Since branches have more information about the ATM cash demand compared to the headquarters, cash inventory at ATMs is usually managed by the branches. Inventory holding and stock-out costs, however, are incurred by the headquarters.**

The paper investigates the optimization of ATM cash inventory by means of genetic algorithm in order to produce optimal upload strategies able to minimize the daily amount of stocked money, still assuring cash dispensing service.

Keywords—Automated Teller Machine; Cash Inventory Management; Genetic Algorithm

I. INTRODUCTION

Decision making in the present time is a complex process. The wrong decision will impact the business or organizations. The application of scientific methods to make decisions to solve business problems can obtain the best or the most appropriate results. The problem of filling the ATM of bank cash machine can be solved by applying Genetic Algorithm. The problem of treasury management to reduce cost of filling the prepaid ATM in a channel banks can be formulated as an optimization problem. Therefore, strategies to find the optimal value can be used to ensure a consistent behavior of refilling and withdrawal of cash by customers in each period.

Genetic Algorithm (GA) is an optimum search method that used the principle of natural selection in biology by simulating genetic evolution. There are five steps in the method: initialise the population, genetic operations, fitness computation, selection and termination. The important steps of GA are the selection step which will select the appropriate chromosomes to be the population to the next generation and genetic operations that are composed of crossover and mutation.

II. PROBLEM FORMULATION

The problem of minimize the cash filled in ATMs is formulated as a minimization of various costs. Given n machines and m periods of consideration, X is the 1st refill, Y is the 2nd refill, and Z is the 3rd refill, the objective function.

Information collected in the past of the ATM withdrawals from July 2012 - December 2013 are used to create an initial population using the random integer numbers. The Genetic Algorithm is run twice. The first round used the objective function (1) then the second round used the objective function (2) with the population from the first round. The Objective Functions are as follows.

GA Round 1: Minimize the difference, comparing with the data from the same month last year, Equation (1).

$$f_1^j(x,y,z) = \left|x_i^j - \mathrm{X}_{(i-12)}^j\right| + \left|y_i^j - \mathrm{Y}_{(i-12)}^j\right| + \left|z_i^j - \mathrm{Z}_{(i-12)}^j\right| \quad (1)$$

GA Round 2: Minimize the difference, comparing with the data of the previous month forecasting, Equation (2).

$$f_2^j(x,y,z) = \left|x_i^j - \mathrm{X}_{(i-1)}^j\right| + \left|y_i^j - \mathrm{Y}_{(i-1)}^j\right| + \left|z_i^j - \mathrm{Z}_{(i-1)}^j\right| \quad (2)$$

Where x , y , z are the prediction of demand in first period (ten days), second period and third period of the month. X , Y , Z are the actual amount of fill in the ATMs for each period. i is the index of month, j is the identification of ATM; j=1,2,3,…,37

The fitness values are normalized with Linear Normalization in Equation (3).

$$E_{\mathrm{i}} = E_{\mathrm{best}} - (\mathrm{r} - 1) \times \lambda \quad (3)$$

Where E_{best} is the best chromosome, r is the index of the order of the sort, and λ is decrement rate (The rate of decline will vary according to the nature of the assessment, lambda used 1).

The encoding of the solution is the concatenation of integer representing each refill of each period. The selection method is Tournament selection according to Equation (4). Where p is the probability of being chosen, n is the number of chromosomes.

$$p \times (1 - p)^n \quad (4)$$

Tournament selection is a method of selecting an individual from a population of individuals in a genetic algorithm. Tournament selection involves running several "tournaments" among a few individuals chosen at random from the population. The winner of each tournament (the one with the best fitness) is selected for crossover. Selection pressure is easily adjusted by changing the tournament size. If the tournament size is larger, weak individuals have a smaller chance to be selected.

The following parameters are used in the run of Genetic Algorithm: population size 400, maximum generation 400, crossover probability 0.8, mutation rate 0.001.

III. RESULTS

- Forecasting Cash ATM

The data between January to March 2014 is used as tested data. The prediction is report every ten days. The ATM number 37 is used to illustrate the quality of the prediction by Genetic Algorithm. The results are shown in Table I.

TABLE I. Data forecast of ATM cash for the first quarter (Year 2014)

number of ATM	month	The cash reserve (days)			Total
		1-10	*11-20*	*21-28,31*	
37	January	56,489,700	46,185,600	73,814,800	176,490,100
37	February	49,694,400	40,445,400	68,195,400	158,335,200
37	March	59,648,400	46,833,000	49,292,500	155,773,900
Total		165,832,500	133,464,000	191,302,700	490,599,200

Note: The unit is THB

- Actual data from bank

Information of bank customers withdraws money from ATMs by data collected from January to March 2014 is shown in Table II.

TABLE II. Actual data of the bank customers for the first quarter (Year 2014)

number of ATM	month	Amount was withdrawn (days)			Total
		1-10	*11-20*	*21-28,31*	
37	January	49,693,800	40,444,100	68,194,800	158,332,700
37	February	59,648,400	46,832,200	49,291,900	155,772,500
37	March	57,037,500	40,419,100	56,659,300	154,115,900
Total		166,379,700	127,695,400	174,146,000	468,221,100

Note: The unit is THB

The difference between the prediction and the actual data is shown in Table III.

The difference is high in January for the first and second period due to the holidays. The bank customers withdraw more than usual. The difference in February and March are more typical.

TABLE III. The difference of the forecast and actual data

Refill Method	Difference of the Month			Total
	January	*February*	*March*	
GAs (forecast) :(A)	176,490,100	158,335,200	155,773,900	490,599,200
Actual Data :(B)	158,332,700	155,772,500	154,115,900	468,221,100
Difference :(A-B)	18,157,400	2,562,700	1,658,000	22,378,100
Percent: 100-(B/A*100)	10.2881 %	1.6185 %	1.0644 %	4.5614 %

In reporting the errors of the prediction, three measurements are used: Mean Absolute Deviation (Eq. 5), Root Mean Square Error (Eq. 6) and Mean Absolute Percent Error (Eq. 7).

$$\text{MAD} = \frac{\sum |(A_t - F_t)|}{n} \quad (5)$$

$$\text{RMSE} = \sqrt{\frac{\sum (A_t - F_t)^2}{n}} \quad (6)$$

$$\text{MAPE} = \frac{\sum(|(A_t - F_t)|/A_t) \times 100}{n} \qquad (7)$$

Where A_t is the actual value, F_t is the forecast value, n is the number of ATM

IV. DISCUSSION

The analysis of the errors is reported in Table IV.

TABLE IV. Discrepancy or error of the forecast with actual data

Month	Criteria of fault		
	MAPE	MAD	RMSE
January	19.2608	17,843.7546	119,595.3757
February	17.0114	16,214.3901	98,628.2843
March	102.3508	19,257.7064	117,140.0546
Total	138.6231	53,315.8511	335,363.7146

From table 4 MAPE values are 19.26 % 17.01 % and 102.35 % for January, February and March 2014 respectively. For March, the bank has stopped the service ATM during the middle of the month and that caused the high value of error.

When compare the current procedure used by the bank with the prediction from Genetic Algorithm to forecast the demand, Genetic Algorithm can reduce the errors in the three months by 26.3694% 17.6318% and -10.7588%, averaging 33.2423% as shown in Fig 1.

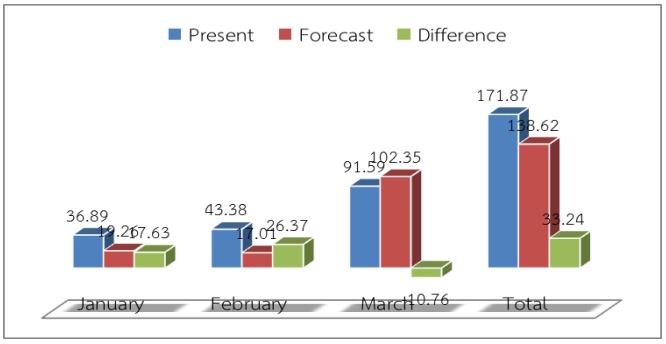

Fig 1. Comparing the errors of the current procedure with the Genetic Algorithm prediction measured by MAPE

With the method used by the bank, the reserve cash in ATMs in January to March 2014 are 203,500,000; 207,000,000; 205,000,000 baht. The reserve for the first quarter of this year is up to 615,500,000 baht. The forecasting method by GA has reduce the amount of cash reserve by 13.2727% 23.5096% and 24.0127% for January, February and March respectively. Average quarterly of the reserve is declined by the amount of 124,900,800 baht as shown in Fig 2.

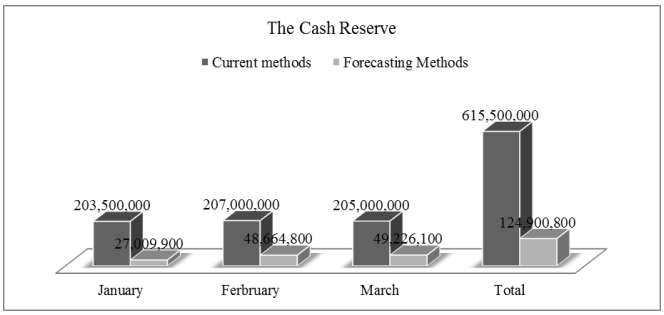

Fig 2. Show a decrease in the amount of cash reserve

V. CONCLUSION

By applying Genetic Algorithm to forecast the demand of the cash from ATM with 37 cabinets in the first quarter of 2014, the bank can reduce the amount of cash reserve almost 20 percent.

It can be concluded that the method of optimizing the refilled of ATM produces a very good result. The bank can save the "waste" cash because the forecast of the usage is reasonably accurate.

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